ARITHMETIC *of the* LD *and* SILVERSMITH

William Jockin

D. VAN NOSTRAND COMPANY
NEW YORK

The Arithmetic

of the

Gold and Silversmith

PREPARED FOR THE USE OF JEWELERS, FOUNDERS, MERCHANTS, ETC., ESPECIALLY FOR THOSE ENGAGED IN THE CONVERSION AND ALLOYING OF GOLD OR OTHER METALS, THE MIXING OF VARIOUS SUBSTANCES, ETC.

BY

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PREFACE

Many works on goldsmithing have been written for the practical jeweler, furnished with tables and recipes for making alloys of gold and silver. Such tables and recipes, however, do not answer all questions which may arise in alloying or calculating the value of gold. Among other serious drawbacks, the tables and recipes being restricted, the artisan is often compelled to make a choice between such as do not exactly suit his needs. Again, the constant use of and reliance on them make his mathematical knowledge dull, which we can see from his strange questions made in this regard, and still more from the incorrect answers given to him by men who should know better.

A mere elementary knowledge of arithmetic is amply sufficient to solve the most complicated problems in alloying and conversion which occur in the work-shop.

On investigating the matter, the writer has found a scarcity of treatises on this subject, and hence the necessity for a special manual which will teach the workman, who has a knowledge of elementary arithmetic, to easily solve all questions of conversion and alloying which may present themselves in his trade.

Such knowledge is of importance not only to every jeweler, but also to all who have to alloy with baser metals, or mix different substances, dry or liquid, and for that purpose I have compiled a series of the most simple and useful rules. As there is no necessity of a manual on the rules of elementary arithmetic, it being supposed that every man who nowadays learns a trade has a knowledge of them, they are explained here only synoptically, my aim being to show how to take advantage of that knowledge of arithmetic to solve all the so-called difficult problems in conversion.

WM. JOCKIN.

PRELIMINARY DEFINITIONS

1. The correct solving of problems in alloying requiring no special knowledge of mathematics, and being of great importance to every person who has to do with it, there should not be a single one who makes an alloy of gold, etc., by guesswork. One of the reasons why so many are at a loss to make the required calculations, although they no doubt possess the necessary knowledge of arithmetic, may be the fact that the primary school books generally contain problems having reference only to articles of commerce, and rarely speak about technical subjects such as alloys, or the value of gold or other alloys. In later days some find it difficult to apply the arithmetical rules learned in school to problems of conversion of metals and the like, especially when they contain the Asiatic word *karat*, which sounds so very mysterious and of which many do not understand the correct meaning. We will try to enlighten them.

2. **Karat.** This word, when expressing the fineness of gold, as in all questions pertaining to the problems, means nothing else but *part*. Thus if we say 14-part or 14-karat gold, it is exactly the same thing, if we have in mind or using the 24-karat scale. It represents no weight.

The reason why, by preference, the word karat is still used, is to clearly designate what scale of fine-

ness we are using, there being two different scales adopted in the goldsmith's trade.

Karat, when used in the valuation of precious stones, expresses a weight which in the United States is 3.2 grains; in London, 3.17; in Paris, 3.18.

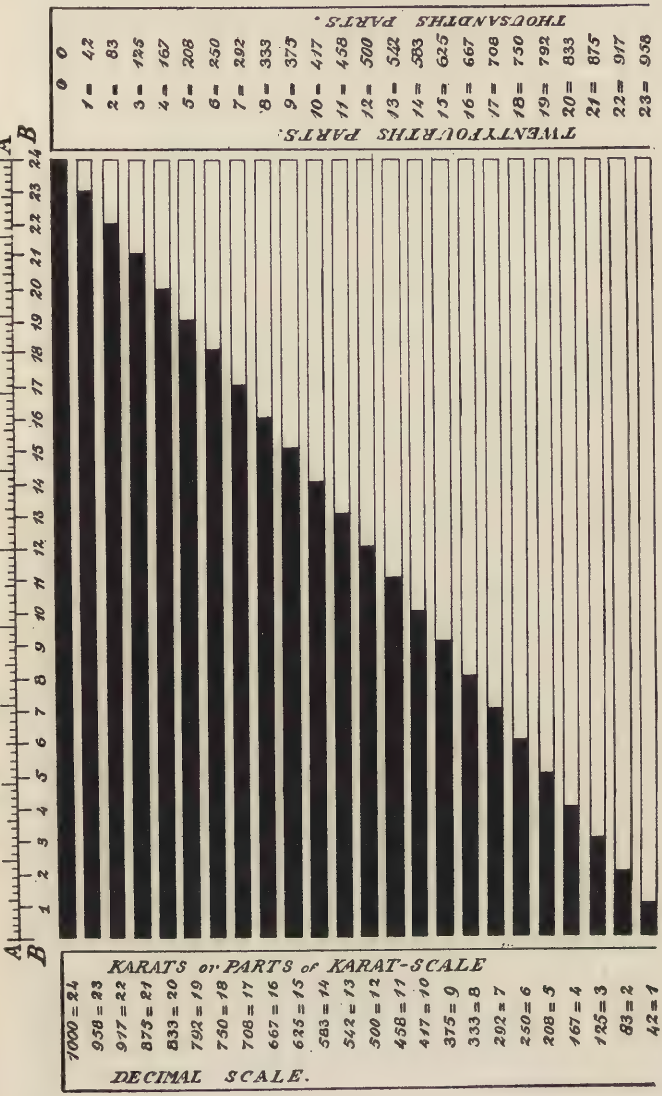
3. **Scales of Fineness.** Only two scales are used in the jewelry trade, to express the fineness of gold, although a scale might be imagined to consist of as many parts as desired. The only science in the use of different scales is, as we shall see later, to find what ratio a certain number of parts of one scale is to that of another.

4. One of these scales, the oldest, supposes *pure gold* to consist of 24 *equal parts*, generally called *karats;* the karat is subdivided into 32 *grains fine*, so that the pure gold is composed of 768 degrees of purity.

Pure silver is supposed to consist of 12 *equal parts*, karats, each one subdivided into 24 equal parts also called *grains fine*, so that pure silver is composed of 288 degrees of purity.

This subdivision of fineness of gold is still generally used by jewelers in the United States and England, while that of the silver is practically obsolete.

By the modern scale, now used alike for gold and silver, the precious metals are supposed to consist of 1000 parts of purity. The degree of fineness of their respective gold and silver coins is determined by all governments by the modern scale. Both scales are here graphically illustrated: scale A the 1000 parts, and B the 24 parts or karat scale.


THOUSANDTHS PARTS.
0 0
1 = 42
2 = 83
3 = 125
4 = 167
5 = 208
6 = 250
7 = 292
8 = 333
9 = 375
10 = 417
11 = 458
12 = 500
13 = 542
14 = 583
15 = 625
16 = 667
17 = 708
18 = 750
19 = 792
20 = 833
21 = 875
22 = 917
23 = 958
TWENTYFOURTHS PARTS.
A
B
KARATS or PARTS of KARAT-SCALE
1000 = 24
958 = 23
917 = 22
875 = 21
833 = 20
792 = 19
750 = 18
708 = 17
667 = 16
625 = 15
583 = 14
542 = 13
500 = 12
458 = 11
417 = 10
375 = 9
333 = 8
292 = 7
250 = 6
208 = 5
167 = 4
125 = 3
83 = 2
42 = 1
DECIMAL SCALE.

5. The smallest subdivisions of A in the illustrations are hundredths of thousand, and those of B are of the full karat. The equivalent of one scale to another can be seen approximately enough to give at the first glance an idea of their respective fineness. The illustration is not made to serve as a guide for comparisons, but merely to inculcate the proper idea what scale, fineness, karats, and parts mean.

6. The illustration further shows 24 ingots representing different grades of fineness. The black parts of the ingots indicate the amount of pure gold contained in each of them, the clear white parts represent the amount of alloy (in gold, any baser metal than gold). In the estimation of its worth the alloy is considered to have no value.

7. The upper ingot thus shows pure gold, *i.e.* gold of 24 karats or 1000 parts fine, as written in the columns on the left side. There is not a single part of alloy in such gold. The one underneath contains 23 karats of gold and 1 part of alloy.

8. It is a peculiarity of the scale B that we say *karats* of gold and *parts* of alloy, not karats of alloy. However, by using scale A we say *parts* of gold and *parts* of alloy. The third ingot contains 22 karats of gold, 2 parts of alloy, or, according to scale A, 916.66 parts of gold, and 83.33 of alloy, and so forth.

9. **Arithmetical Signs.** Although we suppose most every jeweler to remember the signs of arithmetic, nevertheless it will do no harm to explain them here in brief.

The sign $+$ is called *plus*, and signifies addition.

Thus $7+3$ is 10.

The sign $-$ is called *minus*, and signifies subtraction.

Thus $7-3$ is 4.

The sign $\times$ signifies *multiplication*.

Thus 7×3 is 21.

The sign $\div$ signifies *division*. Division is also represented by placing the divisor under the dividend, in the form of a fraction.

Thus $7\div3$, or $\frac{7}{3}$ is $2\frac{1}{3}$.

The sign $=$ is that of *equality*, and denotes that two quantities between which it is placed are equal to each other.

Thus $7+3=10$; $7-3=4$; $7\times3=21$, etc.

The signs : :: : denote proportion. Thus $4:2::6:3$ is to be read, as 4 is to 2, so is 6 to 3; the signs placed in this order indicate that 4 stands in the same ratio to 2 as 6 stands to 3. Many use the sign $=$ (of equality) for the sign :: (double colon).

The sign ? represents the *unknown quantity*, sometimes called the fourth term. Often the letter x is used instead of the query sign (?), or even a simple dash. Thus $4:3::6:?$, or $4:3=6:x$, wherein ? and x represent the unknown or fourth term.

The sign % signifies per cent, by the hundred, and ‰ per mil, by the thousand. Thus 3% means 3 parts of every 100 parts; 3‰ means 3 parts for every 1000 parts.

FINENESS OF GOLD

10. We presuppose every man who attempts alloying gold to thoroughly understand the methods of testing its fineness, a chemical process, the description of which hardly belongs to the subject of arithmetic and is therefore omitted here.

11. Gold Coin, which is extensively used in the alloying of gold, has the following value and legal weight:

United States Gold Coins

	Diameter.	Thickness.	Legal Weight.	
			Grains.	Grams.
	Inch.	Inch.		
Dollar..........$1.00	0.55	0.018	25.8	1.672
Quarter Eagle.... 2.50	0.75	0.034	64.5	4.179
Three Dollars 3.00	0.8	0.034	77.4	5.015
Half Eagle....... 5.00	0.85	0.046	129	8.359
Eagle 10.00	1.05	0.060	258	16.718
Double Eagle 20.00	1.35	0.077	516	33.436

United States coin gold contains 900 parts of pure gold and 100 parts of alloy. Its value is that of pure gold only; the cost of the alloy and of the coinage being borne by the Government. 23.22 grains of pure gold is worth $1.00, so that 1 grain is worth 4.3 cent.

VALUE OF GOLD BASED UPON THE UNITED STATES GOLD COIN

	Karats Fine.	Thousandths Fine.	Value.
23.22 grains = 1.504665 grams	24	1000	$1.00
1 grain	24	1000	0.043
1 gram	24	1000	0.6646
1 grain	1	——	0.00179
1 gram	1	——	0.02769
1 gram	—	1	0.0006646
1 pennyweight	1	——	0.043
1 decigram	1	——	0.002769
1 decigram	—	1	0.00006646

12. **Gold Coins of Foreign Countries.** *Austria*, quadruple ducat and the ducat, 986 fine; ten-crown pieces, 900 fine.

France, 5, 10, 20, 50 and 100 franc pieces, 900 fine; 155 pieces of 20 francs weigh 1 kilogram.

Great Britain, sovereign, pound sterling, 20 shillings, 916.66 fine (22 karats).

Germany, all gold coin 900 fine.

Russia, ½ imperial or 5 roubles before the year 1886, also 3 roubles, 916.66 fine (22 kt.). After 1886, imperials (10 roubles) and ½ imperials (5 roubles), 900 fine.

Spain, 20 and 10 pesetas, 900 fine.

From the foregoing we see that the modern gold coin of the United States and the great powers is established upon the thousand part scale.

WEIGHTS

13. In the United States and England and her possessions, troy weight is used for gold and silver; it consists as follows:

Troy Weight (United States and British).

24 grains = 1 pennyweight (dwt.).

20 pennyweight (480 grains) = 1 ounce (oz.).

12 ounces (240 pennyweights, or 5760 grains) = 1 pound (lb.). The latter is only imaginary.

14. **Avoirdupois or Commercial Weight** (United States and British).

27.34375 grains = 1 dram.

16 drams = 1 ounce = $437\frac{1}{2}$ grains.

16 ounces = 1 pound = 256 drams = 7000 grains.

A troy pound = 0.82286 avoirdupois pound.

An avoirdupois pound = 1.21528 troy pound.

A troy oz. = 1.09714 avoirdupois oz.

An avoirdupois oz. = 0.911458 troy oz.

The grain of the troy, apothecaries' and avoirdupois weights is equal.

15. **Metric Weights.** The gram is the basis of the French weights, and is the weight of a cubic centimeter of distilled water at its maximum density.

1 milligram	=	$\frac{1}{1000}$ gm.	= 0.015432 grains.	
1 centigram	=	$\frac{1}{100}$ gm.	= 0.15432 grains.	
1 decigram	=	$\frac{1}{10}$ gm.	= 1.5432 grains.	
1 gram			= 15.432 grains.	
1 decagram	=	10 gms.	= 1.54.32 grs. =	0.022046 lb. av.
1 hectogram	=	100 gms.	= 1543.2 grs.	= 0.22046 lb. av.
1 kilogram	=	1000 gms.	= 15432 grs.	= 2.2046 lb. av.

These weights are used indiscriminately for gold, apothecaries' and commercial calculations.

SIMPLE PROPORTIONS

16. To the category of simple proportions, also called *single rule of three,* belong all problems in which three quantities are proportionally combined in order to find the fourth one, or in other words, all problems which can be solved by simple proportion. By this rule questions of conversion from one scale to another can be readily solved.

17. Ex. To how many parts of the modern scale corresponds an ingot of gold 22 karats fine?

Explanation. Here we have three known quantities of which two numbers (24 and 1000) are in ratio, and it is required to find the proportional ratio of which only one quantity (22) is given. It is evident that 24 karats contain more thousandths than 22 karats, and consequently the answer sought must be less. We thus have the following proportion:

$$\underset{\text{karats}}{24 : 22} :: \underset{\text{parts}}{1000 : ?} = \frac{1000 \times 22}{24} = 916.66 \text{ parts.}$$

18. Although karats are subdivided into *grains fine* (4), those who make use of the old scale find it more practical to express fractions of karats by decimals. As a difference of from 1 to 3 thousandths of fineness can hardly be detected with certainty in testing gold, the laws of most governments allow such difference in the statements of fineness of manufactured gold articles, and therefore fractions of $\frac{1}{1000}$ parts are generally omitted. We therefore can write as the answer to the foregoing problem either 916, or, as the fraction 0.66 is more than half a unit, we write 917.

19. Ex. If a watch chain 14 karats fine contains 336 grains of pure gold, how much should it contain if it were of 18 karats?

Ans. In this problem we have the reverse of the foregoing, as the greater the fineness of the gold the more pure gold it must contain. Consequently we have the following proportions:

$$\overset{\text{karats}}{14 : 18} :: \overset{\text{grains}}{336} : ? = \frac{336 \times 18}{14} = 432 \text{ grains.}$$

The proportion of Ex. 17 may be interpreted thus:

Greater : less :: greater : less.

In the present one it is,

Less : greater :: less : greater.

From which we conclude, that in order to obtain the correct answer, if the unknown or fourth term is to be less than the third term, we multiply the latter with the smaller and divide by the greater of

the known ratio; if the unknown term is to be greater than the third term, we multiply the latter with the greater and divide by the smaller term of the known ratio, as shown in the foregoing examples.

20. Ex. A formula for an easy flowing gold solder was recommended to T.M.K. It is composed as follows: fine gold 155 grs., fine silver 210 grs.; copper, 60 grs.; brass, 45 grs. However, before using it on gold works of low karats, he wants to know exactly of what fineness his solder is. How can he find that?

Ans. Being given:

	Alloy
Silver	210 grs.
Copper	60 grs.
Brass	45 grs.
Total	315 grs. + 155 grs. of gold = 470 grs.

Here, 470 grains the total weight, stands in ratio with 24 parts, the total of the scale of fineness; then we find the proportional of 155 grains, the gold contained in the solder. Consequently we have the following simple proportion:

$$470 : 155 :: 24 : ? = \frac{24 \times 155}{470} =$$

7.84 karats fineness of the solder.

21. Ex. How much gold should the above formula contain, to make solder of 6 karats fine?

Ans. We know that 6 kt. gold contains 18 parts of alloy; consequently, if those 18 parts weigh 315

grains, we find the proportional of 6 by the following simple proportion:

$18:6::315:?=\frac{315\times 6}{18}=105$ grs. is the amount of fine gold required to make the solder 6 kt. fine.

22. SIMPLIFICATION. In most problems, familiar to the student, he can dispense with writing down the proportion, and solve it by using the following simple reasoning:

23. Ex. If a 14 kt. gold article contains 60 grains of pure gold how much should it contain if it were of 18 kt?

EXPLANATION. If 14 karats or *parts* contain 60 grains of pure gold, 1 karat or part will contain $\frac{1}{14}$ part of 60 grains or $\frac{60}{14}$; and if 1 part contains $\frac{60}{14}$, 18 parts or karats must contain 18 times $\frac{60}{14}$ (1 part) or $\frac{60\times 18}{14}=77.14$.

As multiplying or dividing both terms of a fraction by the same number does not change the value of the fraction, we can still more simplify the present formula by dividing the numerator and denominator by 2. Hence:

$$\frac{\overset{30}{\cancel{60}}\times 18}{\underset{7}{\cancel{14}}}=77.14.$$

24. Ex. If in 16 kt. gold we have 380 grains of pure gold, what is the weight of the alloy?

Ans.

16 kt. (parts) = 380 grs.

1 kt. (parts) = $\frac{380}{16}$ grs.

$$8 \text{ kt. (parts)} = \frac{380 \times 8}{16} = \frac{380 \times \overset{1}{\cancel{8}}}{\underset{2}{\cancel{16}}} = \frac{\overset{190}{\cancel{380}} \times 1}{\underset{1}{\cancel{2}}} = 190 \text{ grs.}$$

190 grains is the weight of the alloy.

PERCENTAGE

25. Many commercial transactions are made by estimating their results to the number 100. It is on that base that interest and value of money, loss and profits, discount, insurance, commission, etc., are calculated. In the jeweler's trade it is often used in estimating the fineness of gold, and in following recipes, alloys, or mixtures, when it is required to add or subtract a certain percentage from certain quantities, etc. It is practically nothing but a rule of three, which according as the question has been posed may offer some difficulty to the beginner, which we will try to elucidate as follows:

26. Ex. It is required to find 9% of 429 grains.

Operation. $100 : 429 :: 9 : x = \frac{9 \times 429}{100} = 38.61.$

It being required to take 9% from 429, we have the proportion, as 100 is to its rate 9%, so must be 429 to its proportional rate, which we have found to be 38.61; but if the question had been put up thus:

27. What becomes of the number 429, after having *subtracted* 9%?

we would again as above find the 9% of 429 and then subtract 38.61, which would be 390.39; but the solution can be obtained directly by subtracting the rate of per cent from 100, then make the following proportion: the number 100 is to 100 less 9% (a smaller number) as is 429 to the proportional, consequently also a smaller number. Hence,

$$100 : 91 :: 429 : ? = \frac{429 \times 91}{100} = 390.39.$$

It is entirely indifferent how we write the proportion, or where we place the unknown term, provided we keep in mind the rule of proportion: greater, less, greater, less; or, less, greater, less, greater, according to circumstances. Thus we can make the proportion as follows:

The greater unsubtracted number, 429, is to the smaller unsubtracted number, 100, as is the unknown subtracted number, ?, to the subtracted number, 91. We have here:

$$\begin{array}{c} 429 : 100 :: \quad ? \quad : 91. \\ \text{greater} : \text{less} :: \text{greater} : \text{less} \end{array}$$

Because the unknown term must be greater than the third term, according to 19 we multiply the third term, 91, with the greater, 429, and divide by the smaller term, 100, of the known ratio. Hence,

$$? = \frac{91 \times 429}{100} = 390.39.$$

28. A number of which 9% has been subtracted is 390.39; what was the number?

EXPLANATION. This question is the reverse of the foregoing, and we therefore reverse the proportion, which becomes:

$$91 : 100 :: 390.39 : ? = \frac{390.39 \times 100}{91} = 429.$$

The first term of the proportion is 100 less its rate; hence 91 is to the number 100, as is 390.39 to the required proportional. We have here, less, greater, less, greater. We can equally well make the proportion thus:

$$\underset{\text{less}}{91} : \underset{\text{greater}}{390.39} :: \underset{\text{less}}{100} : \underset{\text{greater}}{?} = \frac{100 \times 390.39}{91} = 429, \text{ as above.}$$

29. If instead of subtracting the rate of per cent of a number, it must be added, we can as in **27** solve the question in two different ways, either by first finding the 9% of that number and then add it to the number, or directly, by adding the rate of per cent to 100 and make a proportion accordingly.

1st method:

$$100 : 429 :: 9 : ? = \frac{9 \times 429}{100} = 38.61 \qquad \begin{array}{r} 429 \\ 38.61 \\ \hline 467.61 \end{array}$$

2d method:

$$100 : 429 :: 109 : ? = \frac{109 \times 429}{100} = 467.61;$$

or, $$100 : 109 :: 429 : ? = \frac{429 \times 109}{100} = 467.61.$$

30. After having added 9% to a number it has become 467.61; what was that number?

EXPLANATION. As 467.61 represents the number which we want to know *plus* the 9%, the first term of the proportion will be 100 plus the 9%, which is 109; consequently we will have:

$$\underset{\text{greater}}{109} : \underset{\text{less}}{100} :: \underset{\text{greater}}{467.61} : \underset{\text{less}}{?} = \frac{467.61 \times 100}{109} = 429;$$

or which is the same,

$$467.61 : 109 :: \ ? \ : 100 = \frac{100 \times 467.61}{109} = 429.$$

31. From the above questions we can establish the following general rules, taking 9% only as an example.

(1) If required to find what a number will be after adding 9%, the ratio will be 100 : 109, less : greater.

(2) If what it was before having added 9%, the ratio will be 109 : 100, greater : less.

(3) If what it will be after having subtracted 9%, the ratio will be 100 : 91, greater: less.

(4) If what it was before having subtracted 9%, the ratio will be 91 : 100, less : greater.

32. SIMPLIFICATION. The foregoing operations can be simplified by a judicial placing of the decimal point in all multiplications and divisions; that is, if we remember that in *multiplying* a number by 10, 100, 1000, etc., we have only to add respectively one, two, three zeros, etc., to the number, as for instance $9 \times 10 = 90$, $9 \times 100 = 900$, $9 \times 1000 = 9000$.

If the number has a decimal fraction, as for instance 390.39, when multiplying it by 10 no zero is added, as that would not change the value of the number; in this case the decimal point is removed one place to the right, thus: $390.39 \times 10 = 3903.9$. When multiplied by 100 the point is moved two places to the right, as $390.39 \times 100 = 39039$, when multiplied by 1000 it is moved three places to the right, but as there are only two figures after the point and its displacement for one figure, as we have seen, is equal to the addition of a zero to an integral number, we add one zero after having moved the point two figures to the right; thus $390.39 \times 1000 = 390390$.

33. *Dividing* by 10, 100, 1000, etc., is a similar operation, but is done in a reversed manner; *i.e.*, instead of moving the decimal point to the right it is moved to the left; thus $390.39 \div 10 = 39.039$; $390.39 \div 100 = 3.9039$; $390.39 \div 1000 = 0.39039$, etc. If in the integral number there are not figures enough to remove the decimal point, an equivalent number of zeros are placed between the point and the first figure; thus, $390.39 \div 10{,}000 = 0.039039$.

34. Applying these rules to the foregoing examples, we have:

If as in **26**, to find 9% of 429; simply $0.09 \times 429 = 38.61$.

If as in **27**, what becomes of the number 429, after having subtracted 9%? Ans. $4.29 \times 91 = 390.39$.

If as in **30**, a number of which 9% has been subtracted is 390.39; what was that number? Ans. $39039 \div 91 = 429$.

If as in **29**, after having added 9% to a number it has become 467.61, what was that number? Ans. $46761 \div 109 = 429$.

EXAMPLES

35. How much is 90% of 129 grains?

Explanation. We are looking for percentage of 129, which number, being greater than 100, will of course produce a greater unknown fourth term. To obtain this according to **19**, we multiply the third term, 90, with the greater and divide by the smaller term of the known ratio (100:129), which we do thus: $0.90 \times 129 = 116.1$, or which is the same, $90 \times 1.29 = 116.1$, or, $90 \times 129 = 11610$, and then placing the decimal point, which gives 116.1.

It does not matter, as shown above, whether we multiply or divide first, neither does it matter by which one of the multiplicants we place the decimal point, if only we observe where it ought to be in the product after the multiplication is finished (see **32**).

36. How much is 10% of 129 grains?

Ans. $\frac{129}{10} = 12.9$, or, we write directly 12.9 (see **32**).

Verification.

$$\begin{array}{r} 129 \times 90\% = 116.1 \\ 129 \times \underline{10\%} = \underline{\ \ 12.9} \\ 100\% = 129 \end{array}$$

37. How much is 15% of a half eagle whose weight is 129 grains? Ans. $129 \times 0.15 = 19.35$ grs.

38. Per mil, ‰. The same rules can be followed in calculations of per mil (‰).

39. Ex. How much is 9‰ of the number 4650?

Explanation. We first find how many times 1000 is contained in the number 4650. This division we do according to rule **33** by placing a decimal point to the left, then multiply the quotient by the rate. Hence:

$$4.650 \times 9 = 41.85$$

40. Ex. How much is 9‰ of the number 763?

Ans. $\frac{763}{1000} = 0.763 \times 9 = 6.867$

41. Ex. How much is 24‰ of the number 3205?

Ans. $3.205 \times 24 = 76.92$

42. Ex. How much is 24‰ of the number 850?

Ans. $0.850 \times 24 = 20.4$

43. From the fact that the karat scale stands to the modern scale as 24 : 1000 or 24‰, the above operations can be followed in problems where it is required to convert fineness of the modern scale into the karat scale.

44. Ex. What fineness in karat represents an article of gold 500 fine?

Ans. $0.500 \times 24 = 12$ kt.

45. Ex. What is the equivalent in karats of 735, 875, and 900 gold?

Ans.

$$0.735 \times 24 = 17.64 \text{ kt.}$$
$$0.875 \times 24 = 21 \text{ kt.}$$
$$0.900 \times 24 = 21.6 \text{ kt.}$$

The equivalent of 735 is 17.64 kt.; 875 = 21 kt.; 900 = 21.6 kt.

46. The problem of converting the fineness of the karat scale into the modern scale being a reversed question, the operation must consequently also be reversed; *i.e.*, instead of dividing the number of which the equivalent is sought, by 1000, it is multiplied by the latter number, and instead of being multiplied by the rate 24‰, it is divided by that rate.

47. Ex. What is the equivalent in thousandths of 12 kt., 17.64 kt., 21 kt., 21.6 kt., and 14 kt. gold?

ANS. $\frac{12000}{24}=500$, $\frac{17640}{24}=735$,
$\frac{21000}{24}=875$, $\frac{21600}{24}=900$, $\frac{14000}{24}=583.33$.

The equivalent of 12 kt. = 500, of 17.64 = 735, of 21 = 875, of 21.6 = 900, of 14 = $583\frac{1}{3}$.

PROBLEMS OF CONVERSION AND ALLOYING

FIRST KIND

48. Problems of the first kind are those in which the weight and the fineness of the articles being given, it is desired to know what the fineness of the ingot will be when those articles have been melted together.

49. To obtain the solution of such problems, we must multiply the weight of the objects by their degree of fineness, then divide the sum of the products by the total weight of the objects which are used in the melting. The same formulas are applicable to all problems of alloying and mixtures, other than

gold and silver, and their weight may be equivalent to measure, fineness, price, etc. For instance:

50. Ex. A wine merchant mixes 50 gallons of wine at 50¢ the gallon with 25 gallons at 80¢: how much a gallon will the mixed wine cost?

ANS.

$$\begin{array}{lr} 50\text{ gal. at }50¢= & 2500 \\ \underline{25}\text{ gal. at }80¢= & \underline{2000} \\ 75\text{ gal. mixed wine cost} & 4500¢. \end{array}$$

One gallon will cost $4500 \div 75 = 60$¢.

51. Ex. A grocer mixed 150 pounds coffee at 30¢ with 60 pounds at 24¢: how much will the mixed coffee cost per pound?

ANS.

$$\begin{array}{lr} 150\text{ lb. at }30¢= & 4500¢ \\ \underline{60}\text{ lb. at }24¢= & \underline{1440¢} \\ 210\text{ lb. mixed coffee cost} & 5940¢ \end{array}$$

One pound mixed coffee cost $5940 \div 210 = 28.29$¢.

52. Ex. A founder has melted together 360 pounds of copper and 70 pounds of tin. The copper cost 25¢ and the tin 52¢ a pound: what is the price of one pound of the alloy?

ANS.

$$\begin{array}{lr} 360\text{ lb. of copper at }25¢= & 9000¢ \\ \underline{70}\text{ lb. of tin at }52¢= & \underline{3640¢} \\ 430\text{ lb. of alloy cost} & 12640¢ \end{array}$$

One pound of alloy cost $12640 \div 430 = 29.395$¢ or nearly $29\frac{2}{5}$¢.

53. Ex. A jeweler melts together 2 ounces of gold 10 kt. fine, and 1 ounce of gold 14 kt. fine: of what fineness will be the alloy?

It must be observed that the word alloy means baser metal, and also a mixture of metals, which latter it expresses here.

ANS. 2 oz. of gold 10 kt. fine = 20
1 oz. of gold 14 kt. fine = 14
3 oz. 34

Alloy $= 34 \div 3 = 11\frac{1}{3}$ karats fine.

The preceding examples have shown that, in order to solve problems of conversion, we must consider the karats expressing fineness as if they express price, which in reality is the same thing, as the finer the gold the higher is its value or price, then multiply the karats by the weight of each article of gold, and divide the sum of the products by the total weight of the alloy.

54. Ex. Three qualities of gold are molten together, 350 grs. 18 kt. fine, 240 grs. 14 kt. fine, and 45 grs. 20 kt. fine: of what fineness will be the alloy of gold?

ANS.

$$\begin{array}{r r}
350 \times 18 = & 6300 \\
240 \times 14 = & 3360 \\
45 \times 20 = & 900 \\
\hline
635 & 10560
\end{array}$$

$1 = 10560 \div 635 = 16.63$, nearly $16\frac{2}{3}$ kt. fineness of the alloy.

55. H.K. has 2 half eagles, 1 ounce and 4 dwt. of 18 kt., and $2\frac{1}{2}$ ounces of 10 kt. gold. If he melts that together what will be the fineness?

Ans. United States coin gold containing 90% of pure gold is equal to $24 \times 0.9 = 21.6$ karats fine.

$$\begin{array}{lrr} \text{2 half eagles} = & 258 \text{ grs.} \times 21.6 = & 5572.8 \\ \text{1 oz.} + \text{4 dwt.} = & 576 \text{ grs.} \times 18 = & 10368 \\ 2\tfrac{1}{2} \text{ oz.} = & 1200 \text{ grs.} \times 10 = & 12000 \\ \hline & 2034 \qquad\qquad & 27940.8 \end{array}$$

Fineness will be $= 27940.8 \div 2034 = 13.245 = 13$ and nearly $\frac{1}{4}$.

56. Ex. We have 150 grs. of 8 kt. gold, 35 grs. of 10 kt., 200 grs. of 14 kt., 75 grs. of 17 kt. to be melted together. What will be the fineness of the alloy?

Ans.

$$\begin{array}{r} 150 \times 8 = 1200 \\ 35 \times 10 = 350 \\ 200 \times 14 = 2800 \\ 75 \times 17 = 1275 \\ \hline 460 \text{ grs.} = 5625 \end{array}$$

Alloy $= 5625 \div 460$ grs. $= 12.23$ or 12, and nearly $\frac{1}{4}$ kt. fine.

Problems of the Second Kind

57. Problems of the second kind are those of which the fineness or value of the various gold articles is given, and of which we want to know what quantity we must take to obtain an alloy of certain fineness or a mixture of a certain value.

58. To solve problems of this kind we must first observe how much lower in fineness or value will be

the alloy than the articles of a higher fineness or price, and how much finer or more valuable it will be than the articles which are lower in fineness or cheaper. We must then take of these latter a certain quantity to equalize the loss made upon those of a higher fineness or price.

59. In such cases where the required degree of fineness is the mean between the articles of higher and lower fineness, we can equalize by taking as much from one article as from the other. But if the required fineness is nearer to that of the article of lower fineness than to those of higher fineness, we must take more from the former (the lower) and less from the latter (the higher). From which we infer that the quantities which we must take are in an *inverse ratio* between higher and lower fineness. This can be summed up as follows: *Take the differences between the required fineness and the articles of higher fineness, and also between the required fineness and the articles of lower fineness;* the former indicate how many units we must take from the articles of lower fineness, and the latter indicate how many units we must take from those of higher fineness. In other words, they tell us in what proportion the articles must be mixed.

60. This kind of problems is of an indefinite variety, *i.e.*, they admit of many different solutions, for the resultant proportion may be multiplied by any required number (according to circumstances).

EXAMPLES

61. A jeweler has 9 kt. and 18 kt. gold with which he desires to make 14 kt. gold: in what proportion must he take of each?

ANS.

$$\text{Desired fineness } 14 \begin{cases} 18 \ldots\ldots\ldots 5 \text{ difference} \\ \ \ 9 \ldots\ldots\ldots 4 \text{ difference} \end{cases}$$

According to the above rule he must take the differences between 14 and 9 which is 5, and between 14 and 18 which is 4, and place them in a reversed order; those differences then tell him that he must take 5 parts of the 18 kt. gold, and 4 parts of the 9 kt. gold.

62. To prove that our calculation is correct we verify according to Rules **48** and **49** as follows:

$$\begin{array}{ll} 5 \text{ parts at } 18 \text{ kt.} = & 90 \\ \underline{4} \text{ parts at } \ \ 9 \text{ kt.} = & \underline{\ 36} \\ 9 \text{ parts} & = 126 \end{array}$$

One part or alloy $= 126 \div 9 = 14$ kt.

Which proves that he must take in the ratio of 5 from the higher and 4 from the lower gold. This proportion is equal to 10: 8, to 15: 12, to 20: 16, etc., from which we see that problems of that kind are *indefinite* (see **60**).

63. Jeweler X has some 12 kt. gold which he wishes to convert into 14 kt. gold, using 18 kt. to do it. He asks a friend how this can be calculated.

The friend says that he cannot do it and that in order to convert qualities of gold such as 12 kt. and 18 kt. into 14 kt. gold he must know quantities, and have stated on paper how many pennyweights he wishes to convert.

Rules **57**, etc., show that this is not necessary, and that a correct answer can be given by means of a few figures, namely:

$$\text{Desired fineness } 14 \begin{cases} 18 \ldots\ldots\ldots\ldots 2 \\ 12 \ldots\ldots\ldots\ldots 4 \end{cases}$$

which says that in order to make 14 kt. gold we must take 2 parts of the 18 kt. gold and 4 parts of the 12 kt. gold. As stated before (**60** and **62**), the proportion is exactly the same if we take 1 part to 2; 3 to 6; 4 to 8, etc.

64. We can verify the above according to rules **48** and **49**.

$$\begin{array}{ll} 2 \text{ parts at } 18 \text{ kt.} & = 36 \\ \underline{4} \text{ parts at } 12 \text{ kt.} & = \underline{48} \\ 6 \text{ parts} & = 84 \end{array}$$

Alloy $= \frac{84}{6} = 14$ kt.

65. How many per cent of alloy must be added to a five-dollar piece in order to make 18 kt. gold?

Ans. According to **46** and **47** we find the equivalent of 18 karat in thousandths to be: $\frac{18000}{24} = 750$, 750‰ gold contains 250 ‰ of alloy, or, 75% gold contains 25% of alloy; coin gold, or 900‰ gold contains 100‰ of alloy, or, which is the same, 90% gold contains 10% of alloy. Consequently, the difference of alloy between coin gold and 18 kt. gold

is of 15%. But let us not confound. It does not mean that 15% of the weight of the coin must be added. To find this we make the following proportions:

$$75:90=25:?=\frac{\overset{}{\cancel{25}}\times 90}{\underset{3}{\cancel{75}}}=30$$

which says, if for 75 parts of fine gold we must have 25 parts of alloy, then for 90 parts of fine gold there must be 30 parts of alloy in order to make 18 kt. gold. Now, 100 parts of coin gold being composed of 90 pure gold and 10 alloy, we must add 20 parts of alloy, or 20%, in order to convert it to 18 kt. gold, and consequently, to a five-dollar piece, weighing 129 grs., the addition will be, $1.29\times 20=25.8$ grs.

66. Ex. A jeweler has coin gold and 14 kt. gold to make 18 kt. gold: how much, or in what proportion, must he take of each?

Ans. First, we find the equivalent in karats of 900 gold (coin gold), see **43**, etc., which is $0.900\times 24=21.6$ kt.; then we have:

$$\text{Desired fineness } 18\left\{\begin{array}{l} 21.6\ldots\ldots\ldots 4 \\ 14\quad\ldots\ldots\ldots 3.6 \end{array}\right.$$

From which we see that he must take 4 parts of coin gold, and 3.6 parts of the 14 kt. gold, or, which is the same, 20:18, or, 40:36, etc.

Verification, according to **48** and **49**:

$$\begin{array}{lll} 4 & \text{parts at } 21.6 = & 86.4 \\ \underline{3.6} & \text{parts at } 14 = & \underline{50.4} \\ 7.6 & \text{parts} & =136.8 \end{array}$$

Fineness of alloy $=136.8\div 7.6=18$ kt.

67. Ex. A grocer has coffee at 30¢ and at 22¢ a pound, which he wants to mix in order to sell the mixture at 26¢ a pound: how much must he take of each quality? He also wants to make a mixture with coffee at 30¢ and at 23¢ a pound, to sell it at 28¢ a pound: how much must he take of each?

Ans. The price as explained in 57, etc., is treated in the same way as the fineness of gold or carats, and consequently we have:

$$26\begin{cases}30\ldots\ldots\ldots4\\22\ldots\ldots\ldots4\end{cases}\qquad\qquad 28\begin{cases}30\ldots\ldots\ldots5\\23\ldots\ldots\ldots2\end{cases}$$

which says that for the first mixture he must take 4 parts of each, or equal parts, and for the second mixture, or coffee at 28¢, he must take 5 parts of coffee at 30¢, and 2 parts of coffee at 23¢.

EXAMPLES OF THE 1000 PART SCALE

68. A jeweler has gold of 950 and of 800; he would like to make with it gold of 900 fineness: what proportions must he take?

Ans.

$$\text{Desired } 900\begin{cases}950\ldots\ldots\ldots100 \text{ difference}\\800\ldots\ldots\ldots\ \ 50 \text{ difference}\end{cases}$$

He must take in the proportion of 100 of the 950 and 50 of the 800 gold, or (which is the same) 2 to 1.

Verification.

$$\begin{array}{lr}2 \text{ parts at } 950 = & 1900\\ \underline{1} \text{ part at } 800 = & \underline{800}\\ 3 & 2700\end{array}$$

Alloy $= \frac{2700}{3} = 900$, the desired fineness.

69. Ex. We have gold containing $\frac{5}{1000}=0.005$ of copper, and some containing $\frac{200}{1000}=0.2$ of copper: what proportions must we melt in order to get an ingot containing $\frac{10}{1000}=0.01$?

ANS. $$0.01\begin{cases}0.005 \dots\dots\dots\dots 0.19\\ 0.2 \quad \dots\dots\dots\dots 0.005\end{cases}$$

We take in a proportion of 0.19 of the 0.005 and 0.005 of the 0.2.

70. It is easier not to use decimal fractions when expressing the fineness, especially when there is no doubt about the scale we are using. The foregoing example could be written thus:

$$10\begin{cases}5 \dots\dots\dots\dots 190\\ 200 \dots\dots\dots\dots 5\end{cases}$$

in a proportion as 190 to 5, which is the same as 0.19 to 0.005 or $\frac{190}{1000}$ to $\frac{5}{1000}$.

71. Ex. (of the karat scale). We want to make 21 kt. gold by using 18 and 22 kt. gold: what proportions must we take of each?

ANS. $$21\begin{cases}22 \dots\dots\dots\dots 3\\ 18 \dots\dots\dots\dots 1\end{cases}$$

3 parts of the 22 kt., and 1 part of the 18 kt. gold.

72. Ex. A wine merchant has wine at 50¢ and at 75¢ a gallon: how must he mix them to get wine at 60¢ a gallon?

ANS. $$60\begin{cases}75 \dots\dots\dots\dots 10\\ 50 \dots\dots\dots\dots 15\end{cases}$$

He must mix in the ratio as 10 : 15, or 2 : 3, etc.

VERIFICATION.

$$\begin{array}{rcl} 2\times 75 & = & 150 \\ \underline{3}\times 50 & = & \underline{150} \\ 5 & & 300 \end{array}$$

$$1 \text{ gal.} = \tfrac{300}{5} = 60¢$$

73. If we desire to make an alloy of a certain weight and of a certain fineness, of articles of different fineness, we must first find the ratio of the articles; next we make a proportion of which the first term is the sum total of the numbers of the ratio; the second term, one of the numbers of the ratio; and the third term, the total weight of the ingot: the answer will state how much must be taken of each article. The same rule is applicable to all kinds of mixtures, if for instance the fineness is considered as price, the weight as measure or quantity. The following examples will explain this:

74. Ex. A jeweler has 12 kt. and 18 kt. gold with which he wants to make 340 grs. of 14 kt. gold: how much of each quality of gold must he take?

ANS.

$$\text{Desired fineness } 14 \begin{cases} 12 \ldots\ldots\ldots 4 \\ 18 \ldots\ldots\ldots \underline{2} \end{cases}$$

6.sum of the numbers of the ratio.

Having the ratio 4 : 2, we only need by a simple proportion to determine how much of each quality of gold must be taken for the alloy. Hence:

$6 : 4 = 340 : ? = 226\frac{2}{3}$ grs. of the 12 kt. gold

and consequently,

$340 - 226\frac{2}{3} \quad = 113\frac{1}{3}$ of the 18 kt. gold.

75. Ex. A grocer has coffee at 30¢ a pound and at 22¢ a pound: how much must he mix of each quality to obtain 150 pounds at 26¢ a pound?

ANS.

$$\text{Mean price } 26 \begin{cases} 20 \ldots\ldots\ldots 4 \\ 30 \ldots\ldots\ldots 6 \end{cases}$$

$\overline{10}$ sum of the terms of the ratio.

Then we have the proportion:

$$10 : 4 = 150 : ? = \frac{150 \times 4}{10} = 60 \text{ lb. at } 20¢.$$

and $$150 - 60 = 90 \text{ at } 30¢.$$

VERIFICATION.

$$\begin{array}{rr} 60 \times 20 = & 1200 \\ 90 \times 30 = & 2700 \\ \hline 150 \qquad & 3900 \end{array}$$

$1 = \frac{3900}{150} = 26¢$ price of 1 lb. of the mixed coffee.

76. In such instances where articles of gold of more than two grades of fineness are being melted together, and two or more of them be of a higher and one of a lower fineness, or two or more be of a lower and one of a higher fineness, or in short, an equal or unequal number of the articles be of a higher or lower fineness than that which we desire to obtain by the melting, we must take the differences in the same manner as explained above, observing, however, that *the number of the differences* which we place after those of higher fineness be *equal* to the number of the differences which are placed after

the lower fineness, whatever their number may be. The following examples will make this more clear:

77. Ex. H. K. has some 18, 12, and 9 kt. gold: how much must he take of each to make 14 kt. gold?

ANS.

$$14 \begin{cases} 18 \dots\dots\dots\dots 2+5=7 \\ 12 \dots\dots\dots\dots\dots\dots 4 \\ \ \ 9 \dots\dots\dots\dots\dots\dots 4 \end{cases}$$

The differences between the articles of lower fineness 14 and 12, 14 and 9, have been placed after the articles of higher fineness 18, and the difference between 14 and 18 has been placed after the 12 and 9; so that the gold of lower fineness and the gold of higher fineness each have two differences. The calculation shows that in order to obtain 14 kt. gold, H. K. must take 7 parts of the 18 kt., 4 parts of the 12 kt., and 4 parts of the 9 kt. gold.

VERIFICATION:

$$\begin{array}{rcr} 7\times 18 & = & 126 \\ 4\times 12 & = & 48 \\ 4\times 9 & = & 36 \\ \hline 15 & & 210 \end{array}$$

$$\text{Alloyage} = \tfrac{210}{15} = 14 \text{ kt.}$$

78. Ex. A jeweler has 20, 18, 14, and 12 kt. gold which he wants to convert into 14 kt. gold: in what proportion must he take of each?

ANS.

$$14 \begin{cases} 20 \dots\dots\dots\dots\dots\dots 2 \\ 18 \dots\dots\dots\dots\dots\dots 2 \\ 12 \dots\dots\dots\dots 6+4=10 \end{cases}$$

He must take 2 parts of the 20 kt., 2 of the 18 kt., 10 of the 12 kt., and as the mixing of gold of the same fineness does not change the latter, he can add as much of the 14 kt. gold as he desires.

79. Ex. E. Z. has 20, 18, 16, and 9 kt. gold, with which he wants to make 14 kt. alloy: what proportion must he take of each?

Ans.

$$14\begin{cases} 20 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 5 \\ 18 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 5 \\ 16 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 5 \\ \ \ 9 \ldots\ldots\ldots\ldots 2+4+6=12 \end{cases}$$

In order to obtain an alloy of 14 kt. fine he must take in the ratio of 12 parts of the 9 kt., 5 parts of the 16 kt., 5 parts of the 18 kt., and 5 parts of the 20 kt. gold.

80. Ex. O. K. has 21, 19, 12, and 8 kt. gold, with which he desires to make an alloy 14 kt. fine; what proportion must he take of each?

Ans.

$$14\begin{cases} 21 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6 \\ 19 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2 \\ 12 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5 \\ \ \ 8 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 7 \end{cases}$$

He must take 6 parts of the 21, 2 parts of the 19, 5 parts of the 12, and 7 parts of the 8 kt. gold.

It must be observed that here the differences have been exchanged between the extremes of fineness 21 and 8, as also between the intermediates 19 and 12.

81. If we proceed according to rule **76**, the operation will be as follows:

$$14\begin{cases}21 \ldots\ldots\ldots\ldots 6+2=\ \ 8\\ 19 \ldots\ldots\ldots\ldots 6+2=\ \ 8\\ 12 \ldots\ldots\ldots\ldots 7+5=12\\ \ \ 8 \ldots\ldots\ldots\ldots 7+5=12\end{cases}$$

Here the differences between the desired fineness 14, and the articles of higher fineness 21 and 19, have been placed after the articles of higher fineness 21 and 19. We have thus obtained the numbers 8, 8, 12, 12, or if reduced, 2, 2, 3, 3, which answer the question as well as the numbers obtained through the foregoing operation, 6, 2, 5, 7, which is another proof that the problems of the second kind are of an unlimited solution.

82: Let us verify both solutions.

(80)

$$\begin{array}{rcl} 6\times 21 &=& 126\\ 2\times 19 &=& 38\\ 5\times 12 &=& 60\\ 7\times\ 8 &=& 56\\ \hline 20 & & 280 \end{array}\qquad \text{Alloy}=\tfrac{280}{20}=14\text{ kt.}$$

(81)

$$\begin{array}{rcl} 8\times 21 &=& 168\\ 8\times 19 &=& 152\\ 12\times 12 &=& 144\\ 12\times\ 8 &=& 96\\ \hline 40 & & 560 \end{array}\qquad \text{Alloy}=\tfrac{560}{40}=14\text{ kt.}$$

Hence both are correct.

83. Ex. Jeweler Q. has a lot of old gold articles

of different fineness, 6, 10, 12, 14, 18 and 20 kt., of which he wants to make gold 15 kt. fine; what proportion must he take of them?

ANS.

$$15\left\{\begin{array}{l} 20\ldots\ldots 1+3+5+9=18 \\ 18\ldots\ldots 1+3+5+9=18 \\ \\ 14\ldots\ldots\ldots\ldots 5+3=\ 8 \\ 12\ldots\ldots\ldots\ldots 5+3=\ 8 \\ 10\ldots\ldots\ldots\ldots 5+3=\ 8 \\ \ \ 6\ldots\ldots\ldots\ldots 5+3=\ 8 \end{array}\right.$$

The differences between the mean 15, 20, and 18, the higher, have been placed after each of the gold of lower fineness, and the differences between the mean 15 and the articles of lower fineness have been placed after the articles of higher fineness. Thus we have obtained the proportion 18 parts 20, 18 parts 18, 8 parts 14, 8 parts 12, 8 parts 10, 8 parts 6 kt. gold.

84. The case might present itself where gold of two or more grades of fineness is to be melted together and that a given quantity of a certain fineness is to be put in the alloy. In that case, we first find in what ratio the mixture must be made according to the above rules, then by means of the ratio we have thus obtained, we make a simple proportion of which the third term is that of the given quantity of the gold of certain fineness which is to be put in the alloy. The following problem is of that kind:

85. Ex. P. has several gold watch chains of 14 kt., weighing 4 dwts., of which he wants to make 18 kt. gold, by adding 21 kt. gold, how much must he take of the latter?

ANS.

$$18 \begin{cases} 14 \ldots\ldots\ldots\ldots\ldots\ldots 3 \\ 21 \ldots\ldots\ldots\ldots\ldots\ldots 4 \end{cases}$$

He must take in the ratio of 3 : 4, and by means of this ratio we make the following simple proportion: $3:4 = 336 : x = \frac{336 \times 4}{3} = 448$ grs. of the 21 kt. gold are needed for the conversion into 18 kt. gold.

VERIFICATION.

336 grs.	at 14 kt. =	4704
448 grs.	at 21 kt. =	9408
784		14112

Alloy $= \frac{14112}{784} = 18$ kt.

86. If the weight of articles of different fineness of gold, which are to be melted in an alloy, is given, and we want to know what proportion must be taken from gold of other grades of fineness, in order to obtain an alloyage of given fineness, we should first find *the mean fineness of the articles of which the weight is given,* then find in what ratio the other articles must be mixed by comparing their respective fineness, and the found mean fineness of the articles of which the weight is determined, with the fineness we expect to obtain by the melting. When this ratio has also been found, a simple proportion or single rule of three is made of which the third term

will be the total weight of the articles which are required to be mixed in the alloy, and the fourth term will give the solution.

87. Ex. A jeweler has 236 grs. 9kt. and 462 grs. 14 kt. gold: how much 20 kt. gold must he add to make 16 kt. gold?

ANS.

$$\begin{array}{l} 236\times\ 9=2124 \\ 462\times 14=6468 \\ \hline 698 \qquad\quad 8592 \end{array}$$

An alloy of the given quantities would be $=\frac{8592}{698}=$ 12.30 kt. This known, it reduces the problem to: he has gold of 12.30 kt. and of 20 kt. with which to make 16 kt. gold. We have then:

$$16\left\{\begin{array}{l} 12.30\ \ldots\ldots\ldots\ldots\ldots\ 4 \\ 20\ \ldots\ldots\ldots\ldots\ldots\ldots\ 3.7 \end{array}\right.$$

which says that he can make 16 kt. gold by taking 4 parts of 12.30 kt., and 3.7 parts of 20 kt.; but he has 698 grs. at 12.30 kt., how much of the 20 kt. must he add to them?

The following simple proportion will give the answer: $4 : 3.7 = 698 : x = 645$ grs.

VERIFICATION.

$$\begin{array}{lr} 236 \text{ grs. at 9 kt.} = & 2124 \\ 462 \text{ grs. at 14 kt.} = & 6468 \\ 645 \text{ grs. at 20 kt.} = & 12900 \\ \hline 1343 & 21492 \end{array}$$

$$\text{Alloy} = \frac{21492}{1343} = 16 \text{ kt.}$$

Hence the foregoing calculation is correct.

88. In problems of the kind which we are actually explaining, the given quantities might be combined thus, that each one of them in turn becomes an unknown quantity; nevertheless the solutions will be based upon the same principles as those we have already demonstrated.

89. Ex. By melting together gold of two different grades of fineness an alloyage of a total weight of 536 grs. and 14 kt. fine has been obtained; one part of the gold consisted of 220 grs. of 12 kt. fine: what was the weight and fineness of the other part of gold?

Ans. It is evident that if we subtract from the total of the alloy the weight of the known gold, and if from the total of karats we subtract the total of karats of that known part of gold which has been melted in the alloy, the differences will express respectively the weight of gold and the total of karats which have been added, from which we then obtain the grade of fineness. Hence:

$$\begin{array}{lr} 536 \text{ grs. of } 14 \text{ kt.} = & 7504 \\ \underline{220} \text{ grs. of } 12 \text{ kt.} = & \underline{2640} \\ 316 & 4864 \end{array}$$

which shows that 316 grains of a total of 4864 have been added; its fineness therefore was $\frac{4864}{316} = 15.39$ kt.

90. If it be required to know the ratio of the different metals contained in a certain quantity of ingot, we must take each quantity of which the ingot is composed as a numerator of the fractions, which

each will have the total sum of the mixed quantities for denominator; then we take the part expressed by those fractions from the given quantity of which we want to know the ratio.

91. Ex. 5 dwts. of gold, 7 dwts. of silver, and 2 dwts. of copper have been melted together: in what proportion are those metals represented in 1 dwt. of the ingot?

Ans.	5 dwts. gold	$= \frac{5}{14}$ of 24 grs. =	8.57 grs.
	7 dwts. silver	$= \frac{7}{14} = \frac{1}{2}$ of 24 grs. =	12 grs.
	2 dwts. copper	$= \frac{2}{14} = \frac{1}{7}$ of 24 grs. =	3.43 grs.
	14		24.00 grs.

In 24 grains or 1 dwt. of this ingot are contained 8.57 grs. of gold, 12 grs. of silver, 3.43 grs. of copper.

92. The same rules which have been given here for the conversion of gold, as before stated, are also applicable to silver, and the alloying of other metals and the mixing of liquid or dry substances. They also serve to solve questions where it is required to find the mean of different quantities, whatever be their nature, as for instance the mean of the salaries of workmen, the mean of the work done by several workmen, the mean of time required for work performed by several men, etc. The following examples, comprising questions of all kinds, which can be easily solved by the rules we have explained, will soon familiarize the student with their application.

EXAMPLES OF ALL KINDS

93. Ex. A jeweler has 240 grs. 12 kt., and 312 grs. 18 kt. gold, which he melts together, of what fineness will be the alloy?

Ans. Applying rules **48** and **49**,

$$\begin{array}{rcl} 240\times 12 & = & 2880 \\ 312\times 18 & = & 5616 \\ \hline 552 & & 8496 \end{array}$$

$$\text{Alloy} = \tfrac{8496}{552} = 15.39 \text{ kt.}$$

Or if we want to express its fineness in grains we must multiply 8496 kt. by 32 grains and divide the product by the weight 552, which is $\dfrac{8496\times 32}{552} = 492$ grs. fine.

94. Ex. I. L. M. & Sons ask, Which is the best alloy you know of in preparing gold for ring making?

They received from a friend the following formulas:

Nine karats. — To 1 ounce of standard or coin gold, add 1 ounce, 8 dwts., and 21 grs. of alloy, $\frac{2}{3}$ of copper, and $\frac{1}{3}$ of silver.

Ten karats. — To 1 ounce of standard or coin gold, add 1 ounce and 4 dwts. of alloy, $\frac{2}{3}$ of copper, and $\frac{1}{3}$ of silver.

Twelve karats. — To 1 ounce of standard or coin gold, add 16 dwts. and 6 grs. of alloy, $\frac{2}{3}$ of copper, and $\frac{1}{3}$ of silver. Let us verify the above formulas:

9 *karats:*	Alloy	Pure gold
1 oz. or 480 grs. of coin gold contain 10% =	48 grs.	432
1 oz. 8 dwts. and 21 grs. of alloy =	693 grs.	
Total of alloy =	741 grs.	

Hence the proportion: If 9 parts (kt.) are to represent 432 grains, how many grains must then represent the 15 parts of alloy? $9:15=432:x=\frac{432\times 15}{9}=$ 720 grs. should be the total of alloy contained in this gold; consequently the recipe contains 21 grains of alloy too much.

10 *karats:*

	Alloy	Pure gold
1 oz. or 480 grs. of coin gold contain 10% =	48	432
1 oz. and 4 dwts. of alloy =	576	
Total of alloy =	624 grs.	

Hence: $10:14=432:x=\frac{432\times 14}{10}=604.8$ grs. should be the total of alloy contained in this gold; consequently the recipe contains 19.2 grains of alloy too much.

12 *karats:*

	Alloy	Pure gold
1 oz. or 480 grs. of coin gold contain 10% =	48	432
16 dwts. and 6 grs. of alloy =	390	
Total of alloy =	438 grs.	

Hence if 12 parts of gold weigh 432 grains, the 12 parts of alloy must have the same weight, consequently the recipe contains 6 grains of alloy too much.

95. In countries which have severe laws concerning the accurate statement of fineness of gold, an addition of too much alloy may have serious consequences. Let us see how much extra profit has been made by selling a gold article weighing 1173 grains

for 9 kt. gold when it contains 21 grains of alloy more than required.

The extra profit having been made only upon 21 grains in selling them for 9 kt., we must find how much pure gold they should have contained, and this multiplied by the price of gold is the amount of extra profit. Therefore:

$$\overset{\text{kts.}}{24} : 9 = \overset{\text{grs.}}{21} : x = \frac{21 \times 9}{24} = 7.87 \text{ grains};$$

then $7.87 \times 4.3 = 33.84¢$ or about 34¢ extra profit.

96. Ex. What is the loss in selling a gold article of 6 kt. fine which contains 50 grains of pure gold too much?

Ans. We first find, as in the foregoing example, how much pure gold those 50 grains should have contained in being sold for 6 kt. gold. Hence,

$$24 : 6 = 50 : x = \frac{50 \times 6}{24} = 12.50 \text{ grs.}$$

Consequently the loss was $50 - 12.50 = 38.5$ grs. of pure gold at $4.3¢ = 165.55 = \$1.65$ and $\frac{1}{2}¢$.

97. Ex. How much gold and how much alloy is contained in a gold watch chain 583 fine, weighing 15 dwts. and 10 grs.?

Ans. 15 dwts. + 10 grs. = 370 grains.

Then, $1000 : 583 = 370 : x = \dfrac{370 \times 583}{1000} = 215.71$ grs.

or, in applying rule **33** we simply write: $0.583 \times 370 = 215.71$ weight of the gold, and $370 - 215.71 = 154.29$ grains weight of the alloy.

98. Ex. A jeweler has gold 750 and 950 fine, which he wants to use to make gold 900 fine, in what ratio must he take?

ANS.

$$\text{Desired fineness } 900 \left\{ \begin{array}{l} 950 \ldots\ldots\ldots\ldots 150 \\ 750 \ldots\ldots\ldots\ldots \ \ 50 \end{array} \right.$$

He must take in the ratio as 150 parts to 50 or as 3 : 1.

99. Ex. Express in karats gold fine 588, 330, 450, 725, and 950 (see 38, etc.).

ANS.

$$\begin{aligned} 0.588 \times 24 &= 14.11 \text{ kt.} \\ 0.330 \times 24 &= 7.92 \text{ kt.} \\ 0.450 \times 24 &= 10.8 \text{ kt.} \\ 0.725 \times 24 &= 17.4 \text{ kt.} \\ 0.950 \times 24 &= 22.8 \text{ kt.} \end{aligned}$$

which says that 588 = 14.11 kt.; 330 = 7.92 kt.; 450 = 10.8 kt.; 725 = 17.4 kt.; 950 = 22.8 kt.

100. Ex. How many thousandths of gold are contained in 13 karats gold and how many of alloy?

ANS. (See 46.)

$\frac{13000}{24} = 542$ of gold, and $1000 - 542 = 458$ of alloy.

101. Ex. A jeweler has three kinds of gold which he wants to melt together. He has 250 grs. 900 fine, 325 grs. 800 fine, and 50 grs. 950 fine: of what fineness will be the alloy?

ANS.

$$\begin{array}{rcr} 250 \text{ at } 900 &=& 225000 \\ 325 \text{ at } 800 &=& 260000 \\ 50 \text{ at } 950 &=& 47500 \\ \hline 625 & & 532500 \end{array}$$

$$\text{Alloy} = \frac{532500}{625} = 852 \text{ fine.}$$

102. Ex. Find the value of a gold watch chain 18 kt. fine weighing $2\frac{1}{2}$ ounces.

ANS. $2\frac{1}{2}$ oz. = 1200 grs. total weight; pure gold = $24 : 18 = 1200 : x = \frac{1200 \times 18}{24} = 900$ grs.; value = 900 grs. × 4.3¢ = 3870¢ or $38.70.

MELTING POINTS OF METALS

103. The exact melting points are quite uncertain and sometimes differ greatly, even of metals belonging to the same category according to different authorities, as shown by the following table:

METALS	Melting Points in Degrees Centigrade	Authority
Platinum	1460 – 2534	Various
Palladium	1360 – 1950	"
Nickel	1371 – 1600	"
Iron	1250 – 1587	"
Gold	1035	Violle
"	1035 – 1142	Various
"	1142	Daniell
"	1240	Riemsdijk
"	1425	Daniell
Copper	950 – 1398	Various
Silver	916	Deville, Becquerel
"	940	Deville
"	954	Violle
"	954 – 1042	Various
"	1040	Riemsdijk
"	1042	Daniell
Aluminium	600 – 850	Various
Zinc	342 – 450	"
Lead	320 – 335	"
Tin	220 – 246	"

This table shows us which metals to melt first, when alloying, so as not to scald or burn the metals having a much lower melting point.

104. THERMOMETER READINGS. To change degrees of *Centigrade* to the corresponding degrees of *Fahrenheit*, we multiply the centigrade reading by 9, and divide the product by 5, then add 32° to the quotient. Thus:

$$1035° \text{ C} = \left(\frac{1035 \times 9}{5}\right) + 32° = 1863 + 32° = 1895° \text{ Fah.}$$

105. To change degrees of *Fahrenheit* to the corresponding degrees of *Centigrade* the operation must be reversed. We subtract 32° from the Fahrenheit reading, multiply by 5, then divide by 9. Thus:

$$1895° \text{ Fah.} = (1895 - 32) \times 5 \div 9 = 1035° \text{ C.}$$

106. The exact melting points of the constituent metals of an alloy and solders being given, we could easily find the mean melting point of such alloy or solder, but as the physical properties and fusibility of the alloys are quite different from those of the constituents, they cannot be determined accurately in advance by mathematical formulas. In nearly all cases the fusing point of an alloy is lower than the mean of its constituent metals, and in some instances, as in the so-called fusible alloys, it is lower than that of either. Experiments have been made and tables compiled of alloys composed of two metals only, but as the varieties and proportions increase immensely in alloys composed of three or

more metals, no reliable table of the fusing points of such alloys has yet been made up, especially not of alloys having high melting points.

107. Table of *Alloys of Gold and Silver* according to *Erhard* and *Schertel:*

Gold %		Silver %	Melting Point in Degrees Centigrade
100	+	0	1075
80	+	20	1045
60	+	40	1020
40	+	60	995
20	+	80	975
0	+	100	954

108. Table of *Alloys of Silver and Copper* according to *W. Roberts:*

Silver %		Copper %	Melting Point Degrees Centigrade
100	+	0	1040
92.5	+	7.5	931
82.1	+	17.9	886
79.8	+	20.2	887
77.4	+	22.6	856
75	+	25	850
71.9	+	28.1	870.5
63	+	37	847
63	+	37	847
60	+	40	857
57	+	43	900
54.1	+	45.9	920

Silver %		Copper %	Melting Point Degrees Centigrade
50	+	50	941
45.9	+	54.1	961
25	+	75	1114
0	+	100	1330

109. The melting point of silver in the above tables **107** and **108** being widely different, we have made the following table which will combine them:

Gold %		Silver %	Melting Points, Degrees Centigrade: Mean of the Constituents	Mean of Alloys	Mean of the Constituents	Mean of Alloys
100	+	0	1075	1075	1075	1075
90	+	10	1062	1060	1071	1068
80	+	20	1050	1045	1068	1062
70	+	30	1038	1033	1064	1058
60	+	40	1026	1020	1061	1054
50	+	50	1014	1008	1058	1050
40	+	60	1002	995	1054	1046
30	+	70	990	985	1051	1045
20	+	80	978	975	1047	1043
10	+	90	966	965	1043	1042
0	+	100	954	954	1040	1040

110. TABLE OF DIFFERENT ALLOYS.

Lead Parts		Tin Parts	Melting Point Degrees Centigrade	Authority
1	+	1	182–241	Various
1	+	2	182–197	"
1	+	3	181–186	"
1	+	4	187–190	"
1	+	5	194	Kupfer
2	+	1	270	Pillichody
2	+	3	210	"

Lead Parts		Tin Parts		Melting Point Degrees Centigrade	Authority
3	+	1		282	Pillichody
3	+	2		246	Kupfer
4	+	1		292	Pillichody
4	+	3		236	"
5	+	7		184.5–181.9	Various
25	+	1		558	Tomlinson
10	+	1		541	"
5	+	1		511	"
1	+	6		381	"
1	+	5		378	"
5	+	3	+	8 bismuth 94° Cent. alloy of Darcet.	
2	+	9	+	1 zinc 168° Cent.	

111. How can we calculate the mean of the melting points of metals?

Simply by following the rules **48**, etc.

Ex. Give the mean melting point of an alloy of 80% gold at 1075° and 20% silver at 954°.

Ans.

$$\begin{array}{rrl} 80 \times & 1075 = & 86000 \\ 20 \times & 954 = & 19080 \\ \hline 100 & & 105080 \end{array}$$

$$\text{Mean} = \frac{105080}{100} = 1050.8°$$

112. Therefore, the mean of the above alloy should have been 1050°, but according to authorities this alloy is in realty 5° lower or 1045° C (see table, **107**).

Ex. How can we find the equivalent of this number 1045°, if instead of 954° the melting point of silver be taken as 1040°?

Ans. We first find what the mean melting point would have been in this case, and then find the proportional of that mean melting point. Thus:

$$\begin{array}{rr} 80 \times 1075 = & 86000 \\ 20 \times 1040 = & 20800 \\ \hline 100 \qquad\quad & 106800 \end{array}$$

$$\text{Mean} = \tfrac{106800}{100} = 1068°$$

Then:

$$1050 : 1068 = 1045 : x = \frac{1045 \times 1068}{1050} = 1062°$$

113. Having the melting point of the percentage of gold and silver and of the percentage of silver and copper contained in an object of gold, we could find that of the object itself by taking the mean of those two melting points; but, as has been stated above, nothing definite being as yet known about the physical changes in alloys composed of three or more metals, no reliable results can thus be obtained by calculation, and consequently the tables given by some writers on goldsmithing, which quote the exact melting points of gold of the different karats with the precision of one single degree, cannot be trusted.

114. An example of that kind is the following, taken at random:

B. K. C. asks for a *good* formula for 10 kt. gold solder. His adviser tells him to take 140 grs. fine gold; 70 grs. fine silver; 75 grs. copper. Let us verify.

We see at a glance that the solder is composed about half and half, *i.e.*, half of gold (140 parts) and half of alloy (145 parts), consequently that the solder is nearly 12 kt. fine. It is evident from the tables that the gold having a much higher melting point than the silver or copper, that point must increase in alloys containing a greater percentage of gold, and consequently, that the gold article, of 10 kt. fineness, will melt before the solder of 12 kt. fineness flows. Therefore the advice is not recommendable. The solder should always be made of a safe amount lower in fusibility than the gold article to be soldered, as shown by the following formulas recommended by Schlosser:

Hard solder for 18 *kt. gold:* take 9 parts of 18 kt. gold, 2 parts of silver, and 1 part of copper.

Soft solder for 18 *kt. gold:* take 12 parts of 18 kt. gold, 7 parts of silver, and 3 parts of copper.

Solder for 14 *kt. gold:* take 3 parts of 14 kt. gold, 2 parts of silver, and 1 part of copper.

115. Find the fineness of the above solders.

ANS. *Hard solder for* 18 *kt. gold.* 18 kt. gold contains $\frac{18}{24}=\frac{3}{4}$ of gold, and $\frac{6}{24}\times\frac{1}{4}$ of alloy, consequently we have in the 9 parts of 18 kt. gold:

$$9\times\frac{3}{4}=\frac{27}{4}=6.75 \text{ parts of gold, and,}$$
$$9\times\frac{1}{4}=\frac{9}{4}\ =2.25 \text{ parts of alloy.}$$

That makes 6.75 parts of gold and $2.25+2+1=5.25$

parts of alloy in the solder. Its fineness is found by the following proportion:

$$12 : 6.75 = 24 : x = \frac{24 \times 6.75}{12} = 13.50 \text{ kt.}$$

Fineness of the hard solder for 18 kt. gold is $13\frac{1}{2}$ kt.

Soft solder for 18 kt. gold. $12 \times \frac{3}{4} = 9$ parts of gold, and $12 \times \frac{1}{4} = 3$ parts of alloy are contained in the 12 parts of 18 kt. gold. Therefore the solder will contain 9 parts of gold, and $3+7+3=13$ parts of alloy, a total of 22 parts. Hence:

$$22 : 9 = 24 : x = \frac{24 \times 9}{22} = 9.8 \text{ kt.}$$

Fineness of the soft solder for 18 kt. gold is 9.8 kt.

Solder for 14 kt. gold. 14 kt. gold contains $\frac{14}{24} = \frac{7}{12}$ of gold, and $\frac{10}{24} = \frac{5}{12}$ of alloy, consequently 3 parts of 14 kt. gold contains $3 \times \frac{7}{12} = 1.75$ parts of gold, and $3 \times \frac{5}{12} = 1.25$ parts of alloy. The solder, therefore, contains 1.75 parts of gold and $1.25+2+1=4.25$ of alloy, a total of 6 parts. Hence:

$$6 : 1.75 = 24 : x = \frac{24 \times 1.75}{6} = 7 \text{ kt.}$$

Fineness of solder for 14 kt. gold is 7 karat.

EXAMPLES FOR EXERCISE

116. A melts together gold 325 grs. 900 fine; 230 grs. 800 fine, and 45 grs. 950 fine: what will be the fineness of the alloy? ANS. 865 parts.

117. To make type metal 15 lbs. of lead, 4 lbs. of antimony and 1 lb. of tin have been used. Sup-

posing lead to cost 13¢, antimony 15¢, tin 52¢, what will 1 lb. of the alloy cost? Ans. 15.35¢.

118. To make an experiment, we want to have seawater containing 6 lbs. of salt per 100 pints, but the water we get from the sea contains 9 lbs. per 100 pints: how much water must be added to give the desired proportion? Ans. 50 pints.

119. We had 400 grains of gold which we knew was 14 kt. fine, we melted it with 500 grains of gold, of which fineness we were not certain, but expected the alloy to become 18 kt. fine; we obtained 16 kt. instead. Of what fineness were those 500 grains? Ans. 17.6 kt.

120. A merchant has coffee at 40¢, 35¢, 33¢, 30¢ 24¢, and 18¢ a pound; he wants to obtain a mixture of 300 lbs.; taking 50 lbs. of each quality, what will a pound of the mixture cost? Ans. 30¢.

121. Find the equivalent of $\frac{436}{1000}$ in karats, and of $13\frac{1}{2}$ karats in thousandths. Ans. 10.46 kt., 562.5.

122. How much water must be added to 45 gallons of wine at 60¢ to make wine at 50¢ a gallon? Ans. 9 gals.

123. How much 18 kt. gold must be added to 650 grs. 9 kt. gold to make 12 kt. gold? Ans. 325 grs.

124. A grocer has 350 lbs. of coffee at 30¢, 450 lbs. at 28¢, 500 lbs. at 22¢, and 640 lbs. at 18¢. His customers generally ask for coffee at 26¢ a pound, therefore he wants to mix them. Before mixing he

first wants to make one mixture of 280 lbs. by taking from the 30¢ and 22¢ qualities to sell it at 23¢ a pound. He asks (1) how many pounds of each he must take for the first mixture; (2) how much per pound the second mixture will cost.

ANS. (1) 35 lbs. at 30¢ and 245 lbs. at 22¢; (2) 25.41¢.

125. A jeweler has gold of different degrees of fineness, 20 grams 650 fine, 24 grams 725 fine, 18 grams 800 fine, 15 grams 900 fine. He wants to make two alloys of gold of different fineness. One, by taking from the two lowest, 18 grams 700 fine. Find; (1) how much of each must be taken for the first alloy; (2) and of what fineness the second alloy will be.

ANS. (1) 12 grams at 725, 6 grams at 650; (2) 808.5 parts fine.

126. A contractor receives $2700 a week to pay his workmen, which is at the mean rate of $3 a day. He pays them 2 at $8, 50 at $4, 30 at $3, 25 at $1, 28 at 75¢, and 15 at 50¢ a day. Find how much profit the contractor makes a day. ANS. $90.5.

127. A jeweler has been paid at the rate of 51 dwts. 12 kt. fine for a gold article which he has made. He used for it 4 dwts. 18 kt., 5 dwts. 14 kt., 12 dwts. 12 kt., and 30 dwts. 9 kt. fine; how much has he overcharged his customer, supposing the value of 1 dwt. 1 kt. gold to be 4¢? ANS. $2.24.

128. A wine merchant has 125 gallons of wine

at 75¢ a gallon: how much water must he add to make wine at 60¢ a gallon? Ans. $18\frac{3}{4}$ gallons.

129. A jeweler has 2 oz. 4 dwts. 18 kt. gold: how much alloy must he add to make it 14 kt. fine?

Ans. 301.71 grains.

130. Find the price of plumbers' solder per pound, composed of 2 lbs. of tin at 48¢ and 1 lb. of lead at 12¢. Ans. 36¢.

131. Find the price of 1 lb. of spelter solder composed of 16 lbs. of copper at 26¢, and 12 lbs. of zinc at 9¢. Ans. 18.71¢.

132. Find the fineness of gold composed of 124 grs. of 18 kt. and 350 grs. of 14 kt. gold. Ans. 15.04 kt.

133. Stereotype metal costing 17.8¢ a pound is composed of 48 lbs. of lead at 15¢, 1 lb. of tin at 49¢, and 6 lbs. of antimony. What is the price a pound of antimony? Ans. 35¢.

134. An alloy of gold, weight 13 dwts. and 17 kt. fine, has been composed of 6 dwts. 18 kt., 5 dwts. 14 kt., and 2 dwts. of gold, of which it is required to find the fineness. Ans. $11\frac{1}{2}$ kt.

135. An alloy contains 45% of gold; find the equivalent in twenty-fourths and in thousandths.

Ans. $\dfrac{10.8}{24} = \frac{450}{1000} = 0.450.$

136. An article weighing 16 dwts. contains 65% of gold: (1) of what fineness is the article, and (2) how much pure gold does it contain?

Ans. (1) $\dfrac{15.6}{24} = 15.6$ kt. or $\frac{650}{1000}$ or .650; (2) 249.6 grains.

EUROPEAN LAWS RELATING TO FINENESS

OF

GOLD AND SILVER

137. The following table of laws has been compiled by the Swiss Federal Bureau of Gold and Silver Products for the benefit of manufacturers and exporters:

Country	Control	Fineness of Alloys	Principal Provisions
Austria-Hungeria	Obligatory. Laws of Aug 19, 1865, and May 23, 1875	Gold: 0.920, 0.840, 0.750, 0.580. Silver: 0.950, 0.900, 0.800, 0.750	The maker's mark is obligatory.
Belgium	Optional. (Law of June 5, 1868)	Gold: 0.800, 0.750. Silver: 0.900, 0.800	Works which do not correspond to the indicated fineness receive the stamp of a lower quality.
Denmark	Optional. (Law of April 5, 1888)	All fineness to a minimum of 0.585 for gold, and 0.826 for silver.	Works must not have any lower mark than the lowest prescribed fineness.
England	Obligatory. (Different laws, 1880–1891)	Gold: 0.916, 0.833, 0.750, 0.625, 0.500, 0.375. Silver: 0.925	The stamp is marked by the jewelers' corporations under control of the State.
France	Obligatory. (Law of brumaire year VI, 11 Nov. 1797)	Gold: 0.920, 0.840, 0.750. Silver: 0.950, 0.800. Allowed for articles to be exported. Gold: 0.583	Works which do not correspond to the indicated quality are cut. Special stamps for imported ware.
Germany	Law of July 16, 1884	Any fineness for jewelry for all other works the lowest is 0.585 for silver.	Indications of fineness must be made in thousandths. All works must be provided with the manufacturers mark and the imperial crown (in the sun sign for gold, and the moon sign for silver; this latter is forbidden for jewelry.
Holland	Optional. (Law of Sept., 1852)	Gold: 0.916, 0.833, 0.750. Silver: 0 934, 0.833	The maker's mark is obligatory. Special stamps for imported ware.
Italy	Optional. (Law of May 3, 1873)	Gold: 0.900, 0.750, 0.500. Silver: 0.950, 0.900, 0.800	Works which do not correspond to the indicated fineness receive the stamp of a lower quality.

EUROPEAN LAWS RELATING TO FINENESS OF GOLD AND SILVER. — *Concluded.*

Country	Control	Fineness of Alloys	Principal Provisions
Norway	Obligatory.	Gold: 0.750, 0 583, 0.500. Silver: 0.830	The indication to fineness and the maker's mark are obligatory.
Portugal ...	Obligatory. (Rules of Feb. 10, 1886, and Aug. 9, and 25, 1891)	Gold: 0.750, 0.580. Silver: 0.800	The aforesaid qualities are for watch cases. These qualities are higher for other objects.
Russia	Obligatory. (Rules of July 1 and 13, 1896)	Gold: 0.948 (91), 0.854 (82), 0.750 (72), $0.583\frac{1}{3}$ (56). Silver: 0 948 (91), $0.916\frac{2}{3}$ (88), 0.875 (84)	No parts of the objects can be lower than the indicated fineness. The stamp indicates the fineness by "Zolotniks."
Servia	Obligatory. (Law of March 3, 1834	Gold: 0.920, 0.840, 0.750. 0.580. Silver: 0.950, 0.900, 0.800, 0.750	The maker's mark is obligatory.
Spain	Obligatory. (Different ordinances since 1771)	Gold: 0.916, 0.833, 0.750. Silver: 0.916, 0.750	Divers provisions seldom applied.
Sweden	Obligatory. (Rules of 1759)	Gold: 0.969, 0.833, 0.750. Silver: $0.812\frac{1}{2}$	The indications of fineness, the place of stamping, of the year and the maker's mark are obligatory.
Switzerland.	Obligatory for all watch cases that are marked with a legal stamp. Optional for jewelry which is needed for educational purposes. (Federal law of Dec. 23, 1880)	Gold: 0.750, 0.583. Silver: 0.875, 0.800	Works which have not been officially controlled, must not have any other indications than that of their real fineness; if they are marked by such fineness, the maker's mark is obligatory. The law has no final character.
Turkey	Obligatory	Silver: 0.900	No limitations for gold.

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